Deutsches Geodätisches Forschungsinstitut (DGFI-TUM)
Technische Universität München

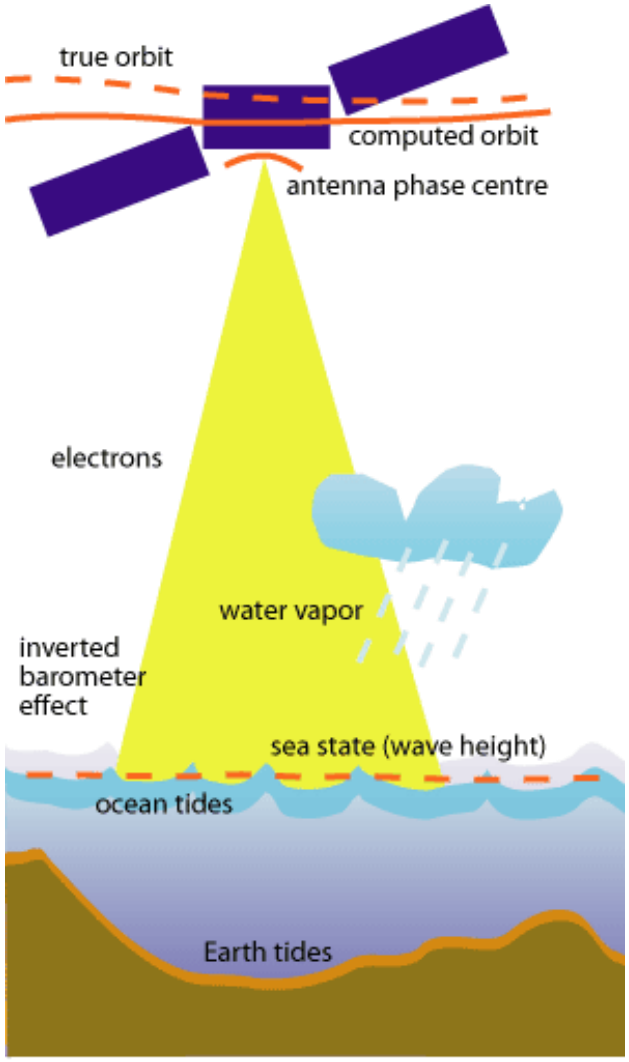
Recent advances in coastal altimetry and implications for sea level monitoring closer to the coast

Marcello Passaro

Satellite Activity | Designing observing systems for ocean boundaries,

16th September 2021

Introduction



My message:

Reliable coastal sea level measurements from remote sensing are now a reality (public dataset exists, results are being analysed).

Improvements in treatment of the radar echo and its adjustements, coupled with new technologies on new missions, made it possible.

Retracking (improvements in signal processing)

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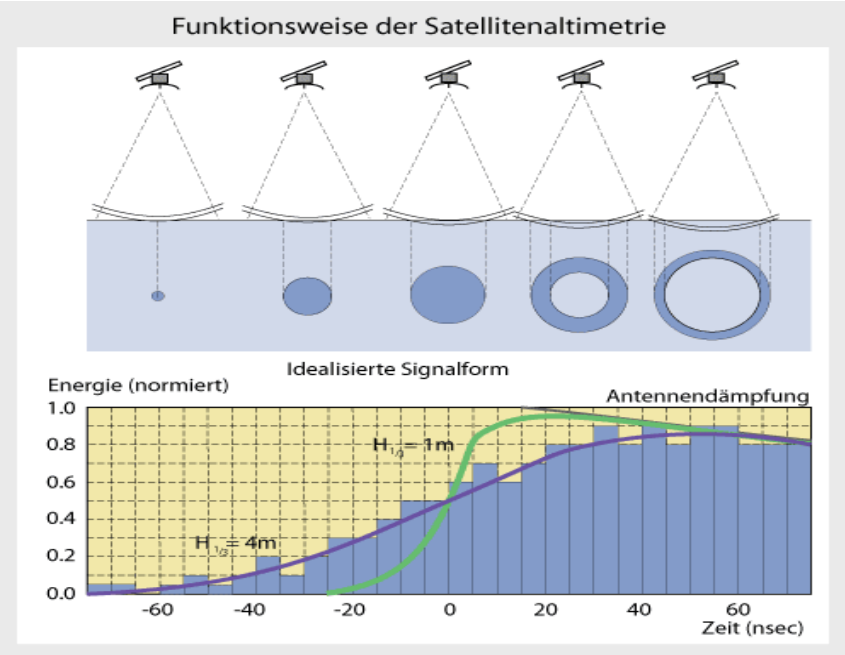
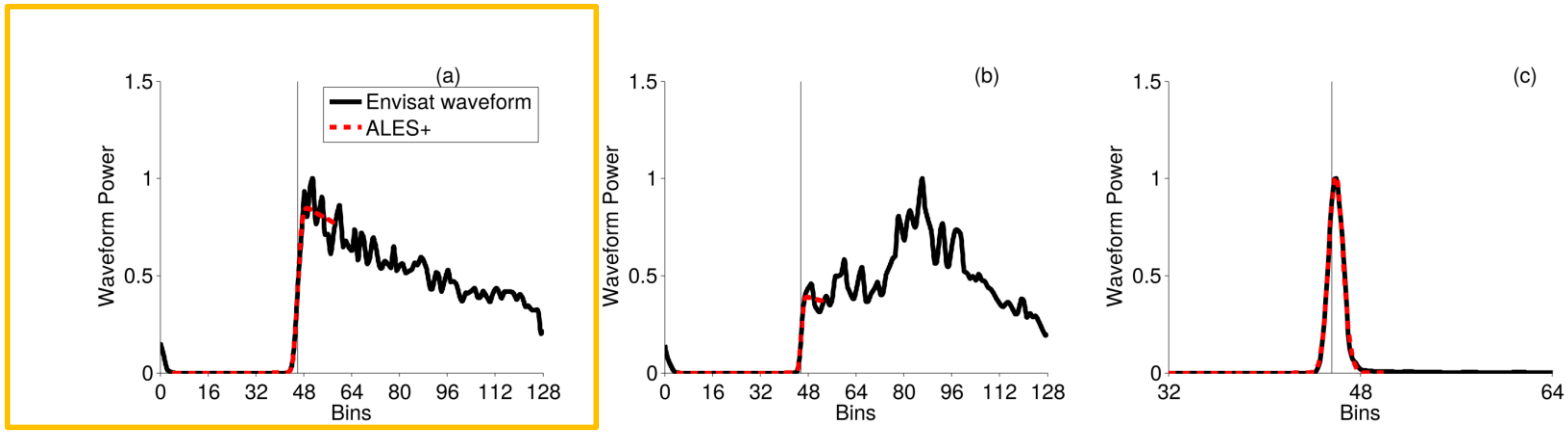
In the Open Ocean, the signal conforms to a known model

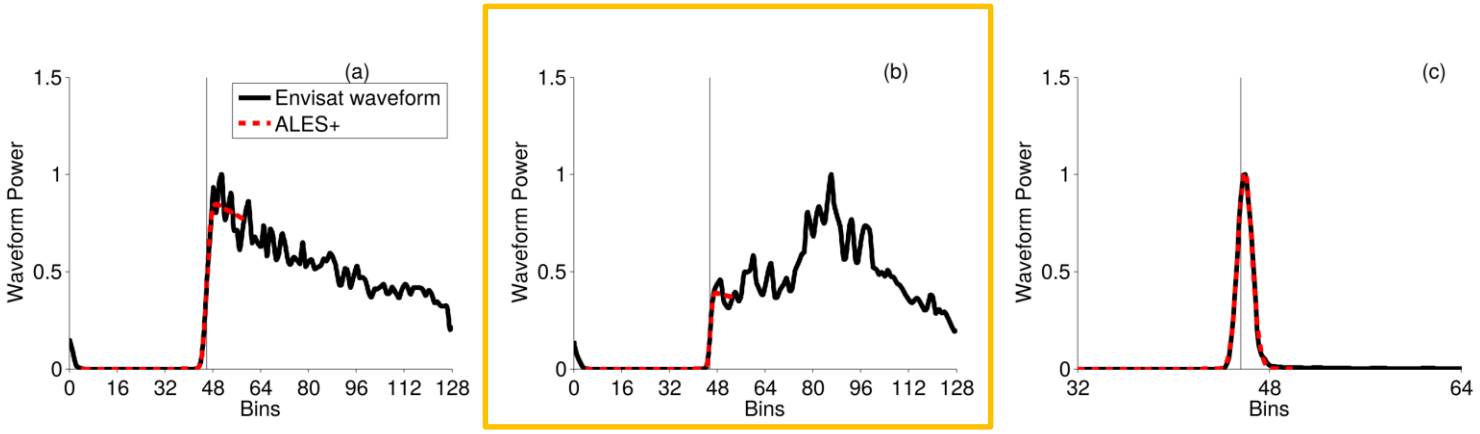




Source: Passaro et al., 2018, [10.1016/j.rse.2018.02.074](https://doi.org/10.1016/j.rse.2018.02.074)

Retracking (improvements in signal processing)

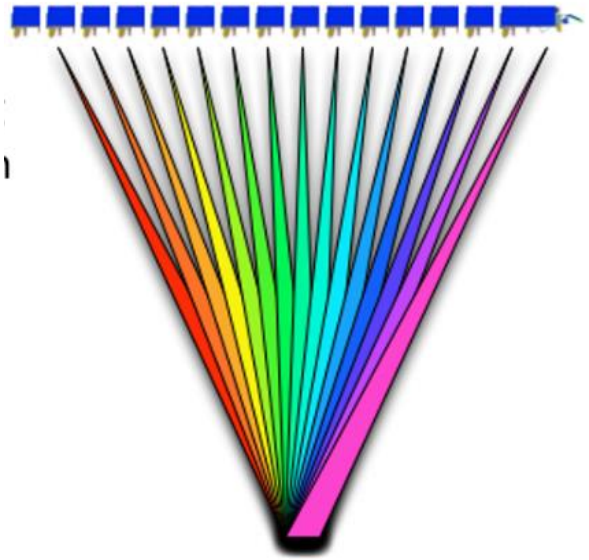
In the Coastal zone, the waveforms are often corrupted by the intrusion of land or by areas of different backscatter in the footprint



New missions and technologies

New missions and technologies

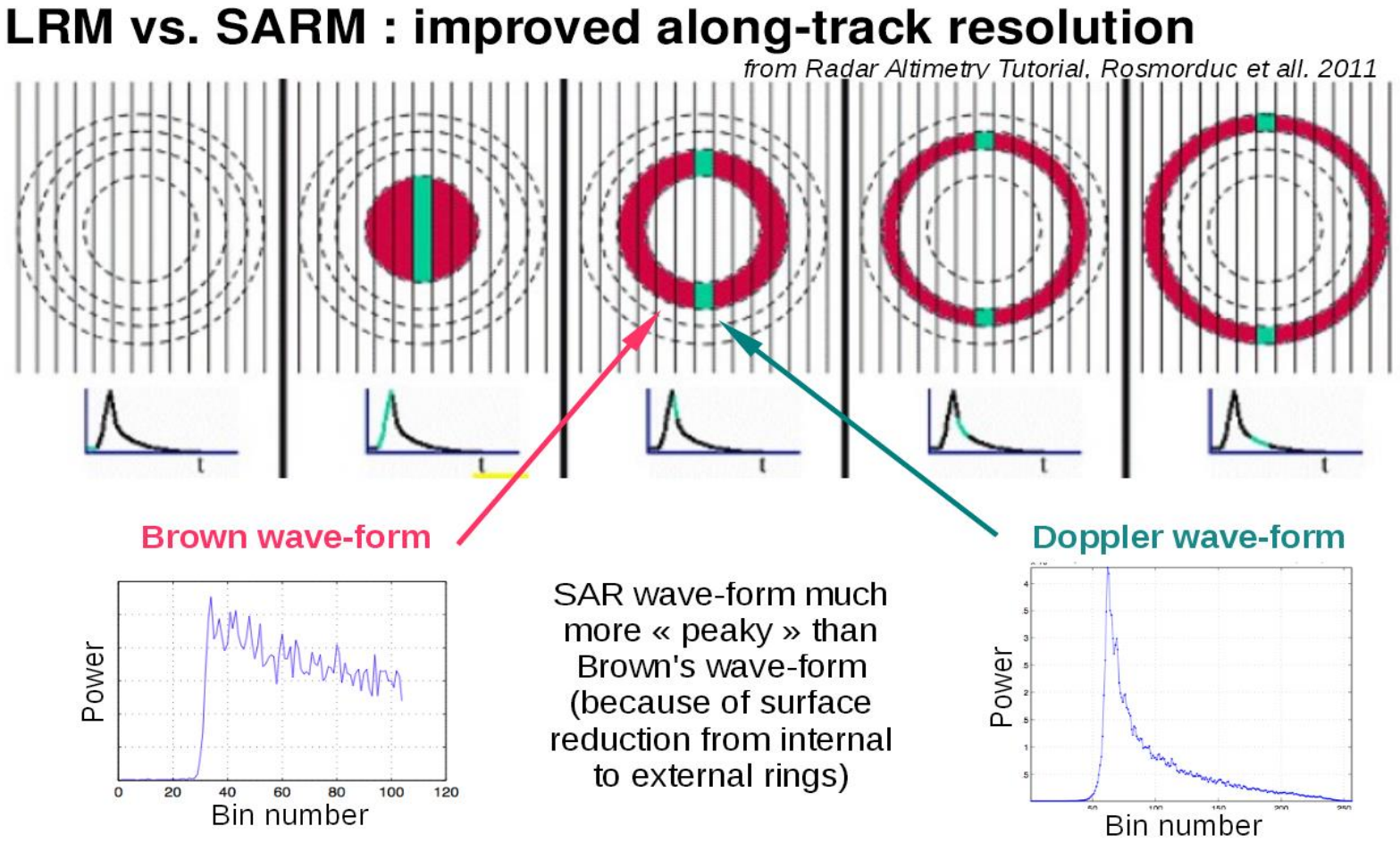
„SAR“ and „Fully-Focused SAR“ Altimetry, improvements compared to the „low-resolution mode“



In comparison to LRM, the energy from subsequent delay-corrected acquisitions is not wasted but focused (relocated) at nadir, increasing the Signal-to-noise Ratio of the leading edge

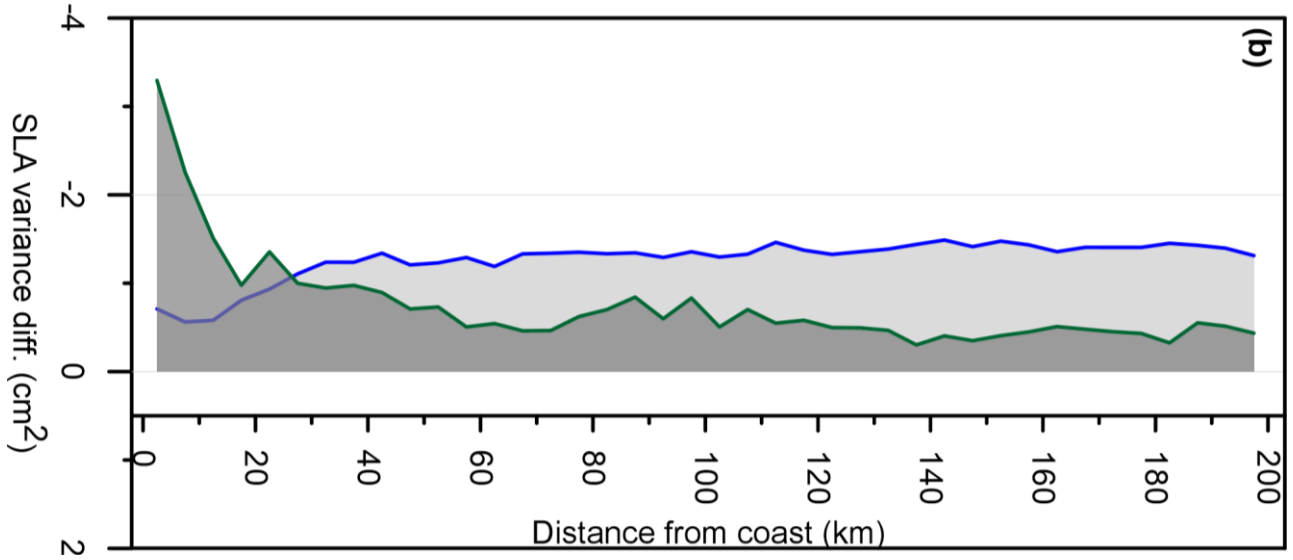
For an overview: Restano et al., 2020, Advanced Altimetry, in the Coastal Altimetry Training: https://www.coastalaltimetry.org/NikalWebsitePortal/coastal-altimetry-workshop/esa/ExtraContent/ContentPage?page=9

New missions and technologies



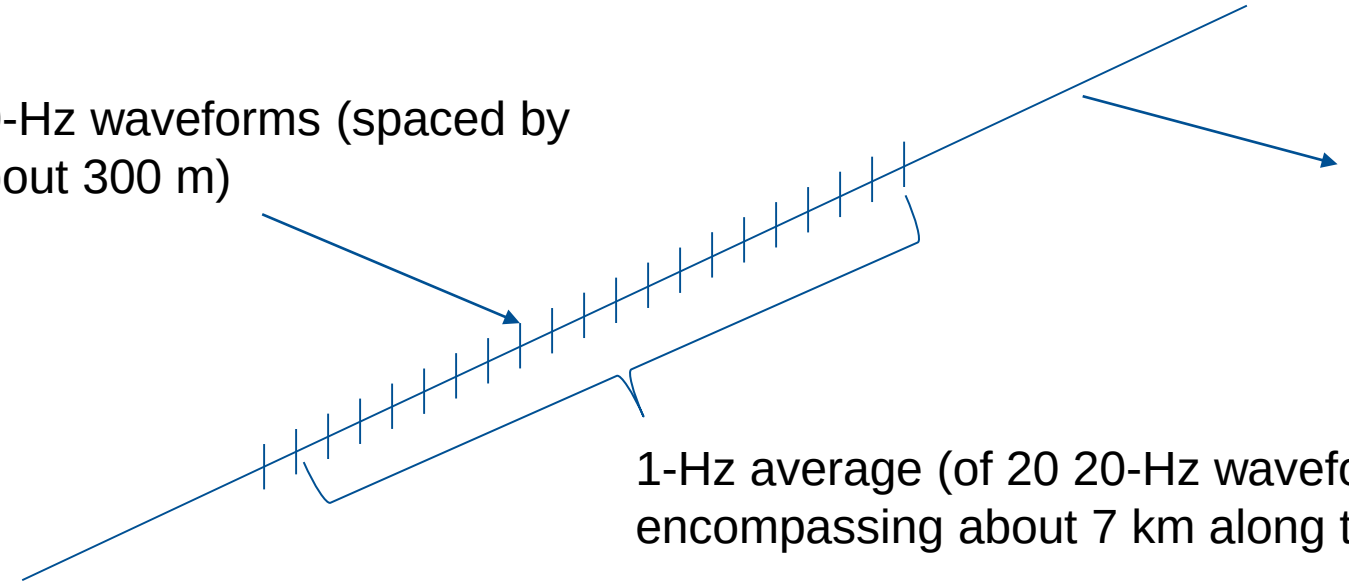
Geophysical Adjustments

- Altimetry signal is delayed by the presence of water vapour in the atmosphere
- On board measurements are sub-optimal in the coastal zone (due to land interference)
- Modern methods (see GPD+) combine a better outlier detection, with the use of model data and in-situ measurements from GNSS stations where possible and needed

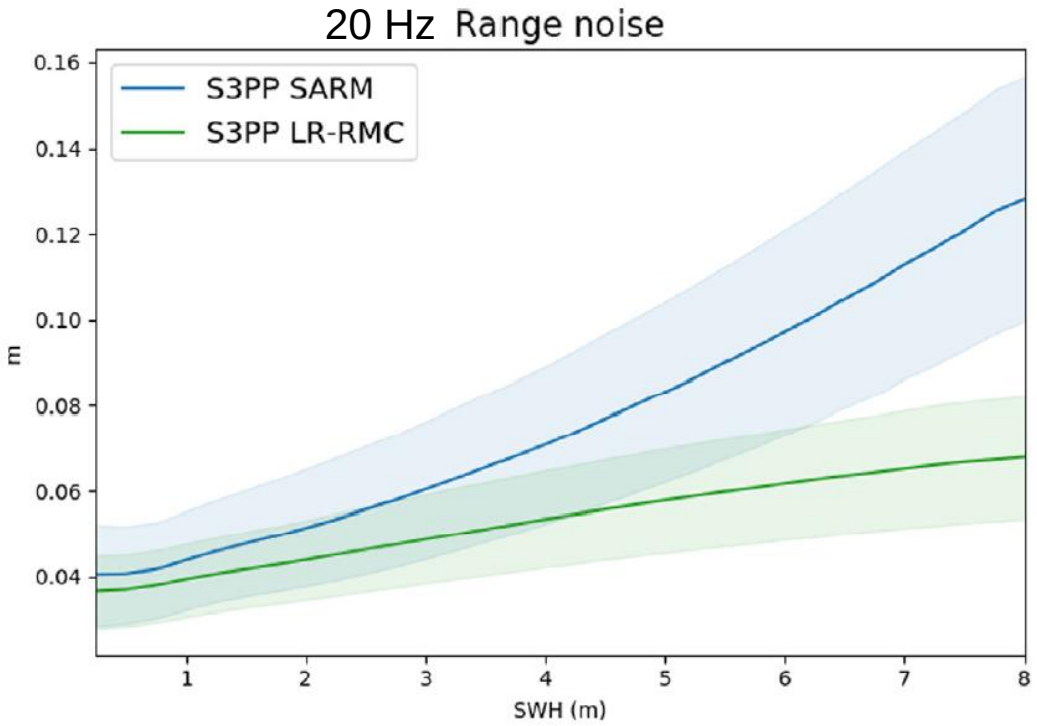


Green curve: the sea level variance difference obtained using GPD+ instead of on-board corrections shoots up in the last 20 km from the coast (from Lazaro et al., 2020, https://doi.org/10.5194/essd-12-3205-2020)

Getting more precise…



Getting more precise…



From Moreau et al., 2020, https://doi.org/10.1016/j.asr.2020.12.038

Currently at about 5 cm in standard ocean conditions, for Sentinel 3 SAR Altimetry…and improving!

…to characterise coastal currents, for example

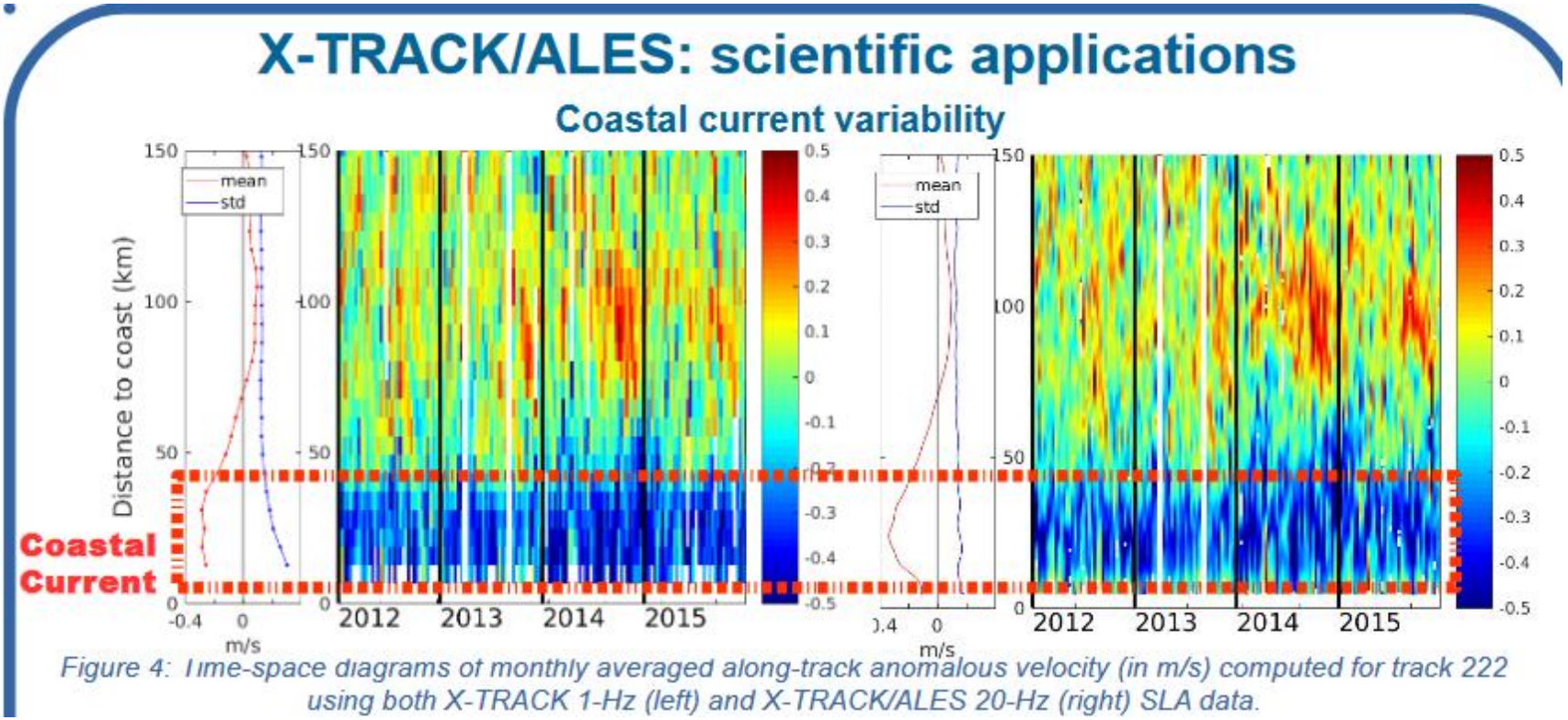
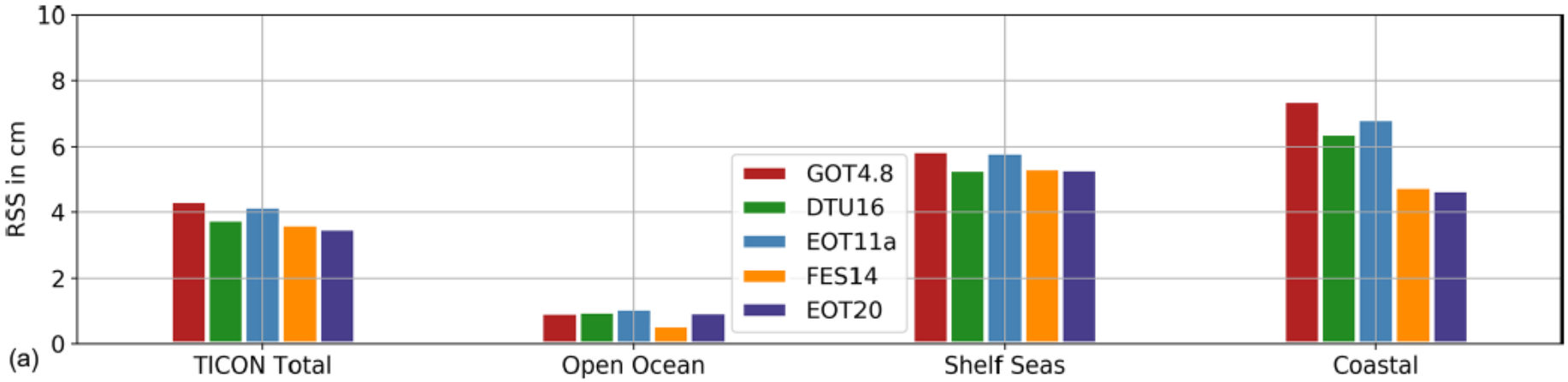


Figure 4: Time-space diagrams of monthly averaged along-track anomalous velocity (in m/s) computed for track 222 using both X-TRACK 1-Hz (left) and X-TRACK/ALES 20-Hz (right) SLA data.

From Leger&Birol, 2020, Coastal Altimetry Training. Example using ESA Sea Level CCI regional XTRACK/ALES product

Tides in the coastal zone

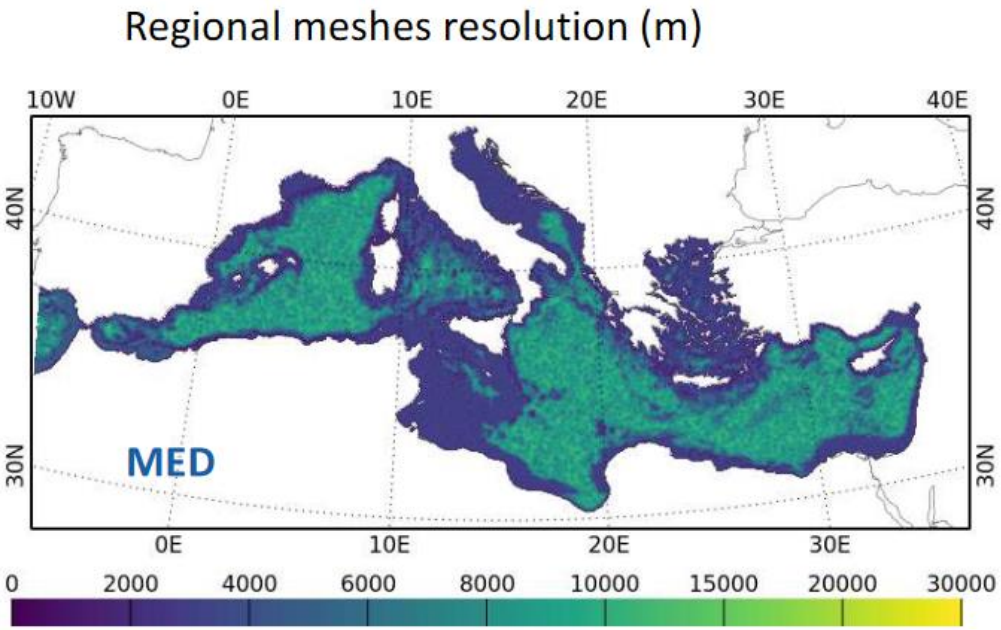
Tides

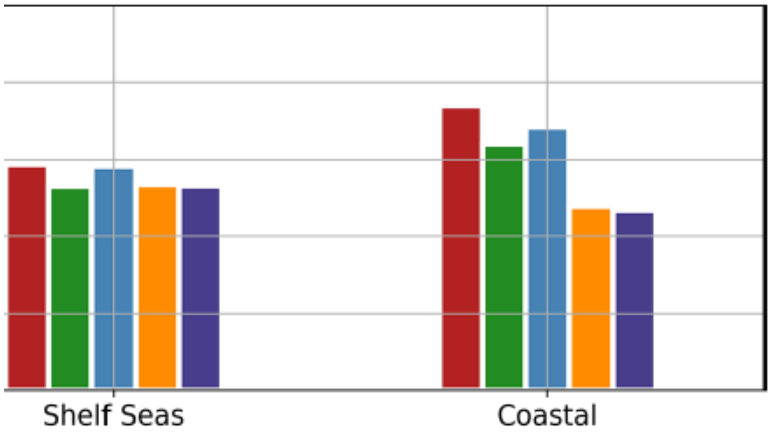


From Hart-Davis et al., https://doi.org/10.17882/79489

Residual some of squares, i.e. discrepancy between tide models and estimations from in-situ data. Some of the models available show notable progresses in the coastal zone (defined as shallower than 10 m depth).

Tides

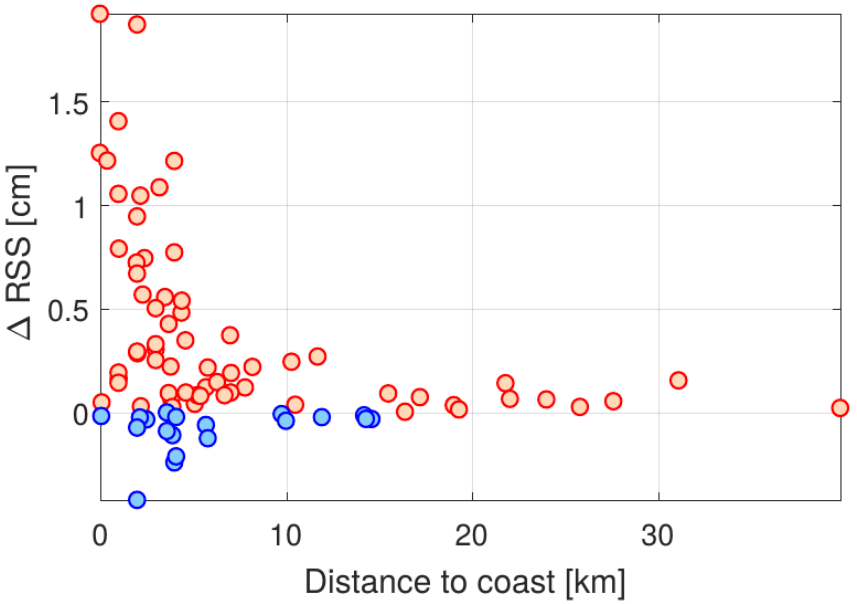


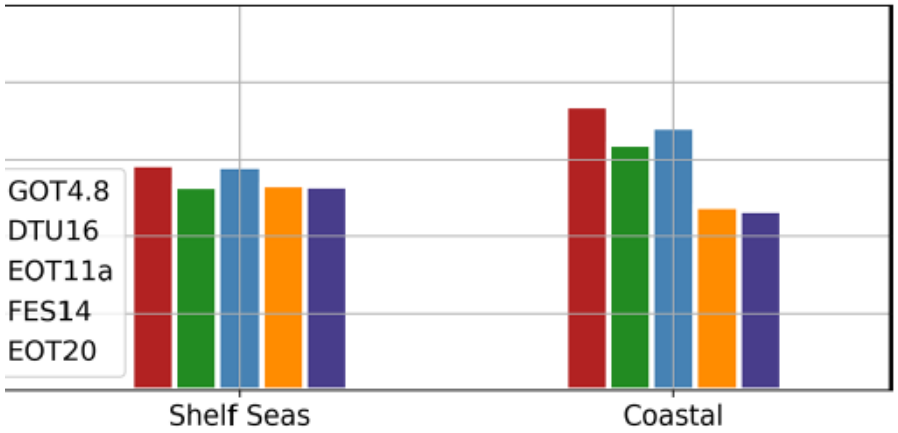


From Carrere et al., OSTST2020

- High resolution regional meshes
- Improved bathymetry, validated through hydrodynamic modelling

Tides





Red = improvement in the RSS at different tide gauges when using reprocessed altimetry data, from Piccioni et al., 2018 [10.3390/rs10050700](https://doi.org/10.3390/rs10050700)

- High resolution regional meshes
- Improved bathymetry, validated through hydrodynamic modelling
- Use of improved coastal altimetry dataset

Coastal Sea Level Trend

All of the cited progresses have been recently put together to estimate and validate for the first time coastal sea level trends, comparing „as close to coast as possible“ w.r.t. 15 km away (so, still very coastal…)

The Climate Change Initiative Coastal Sea Level Team, Nature Scientific Data 2020, 10.1038/s41597-020-00694-w

Sea Level Trend at the Coast from Altimetry

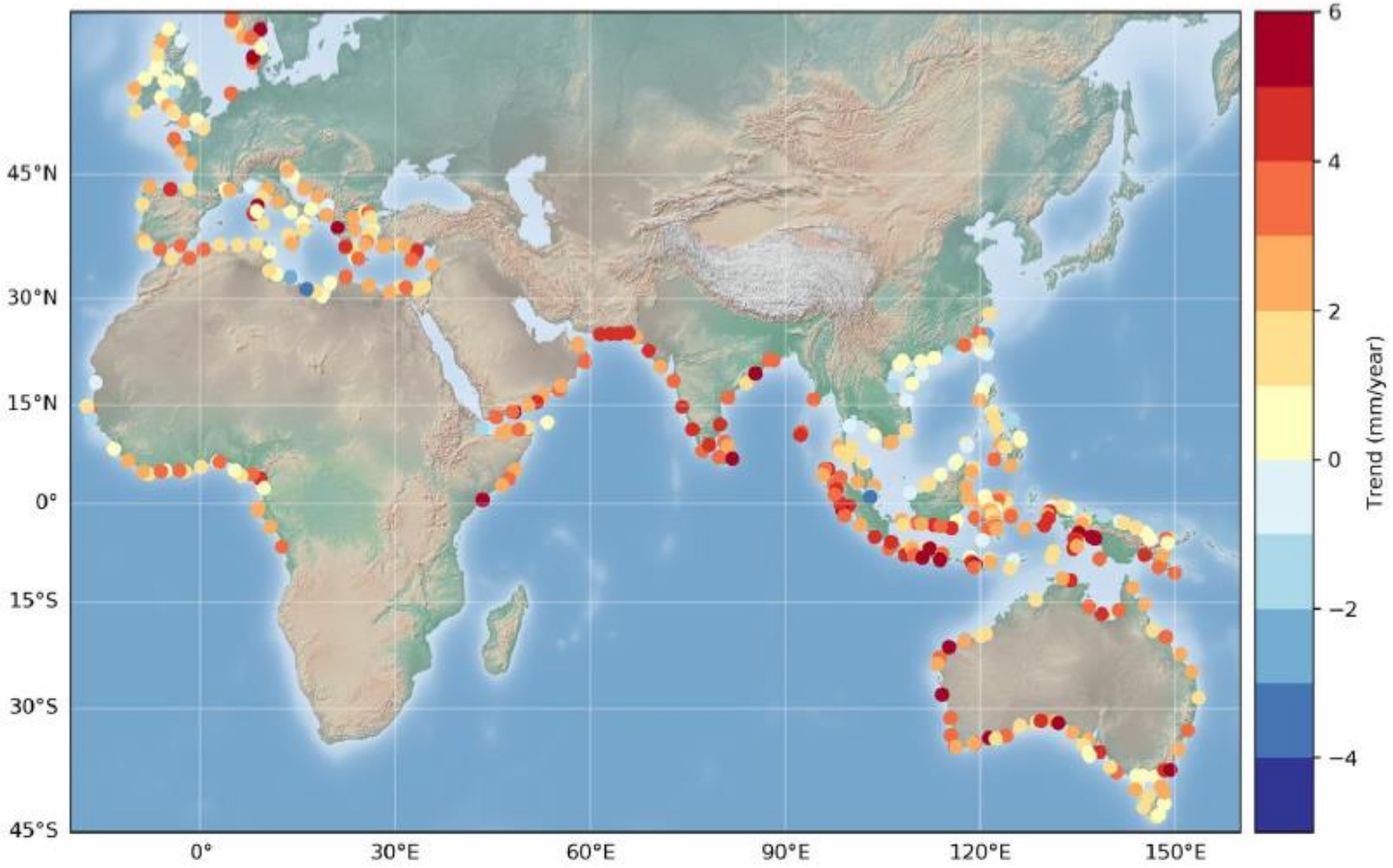


Fig. 9 Coastal sea level trends (mm/yr) at the first valid point from the coast at the 429 selected sites.

How close can we get?

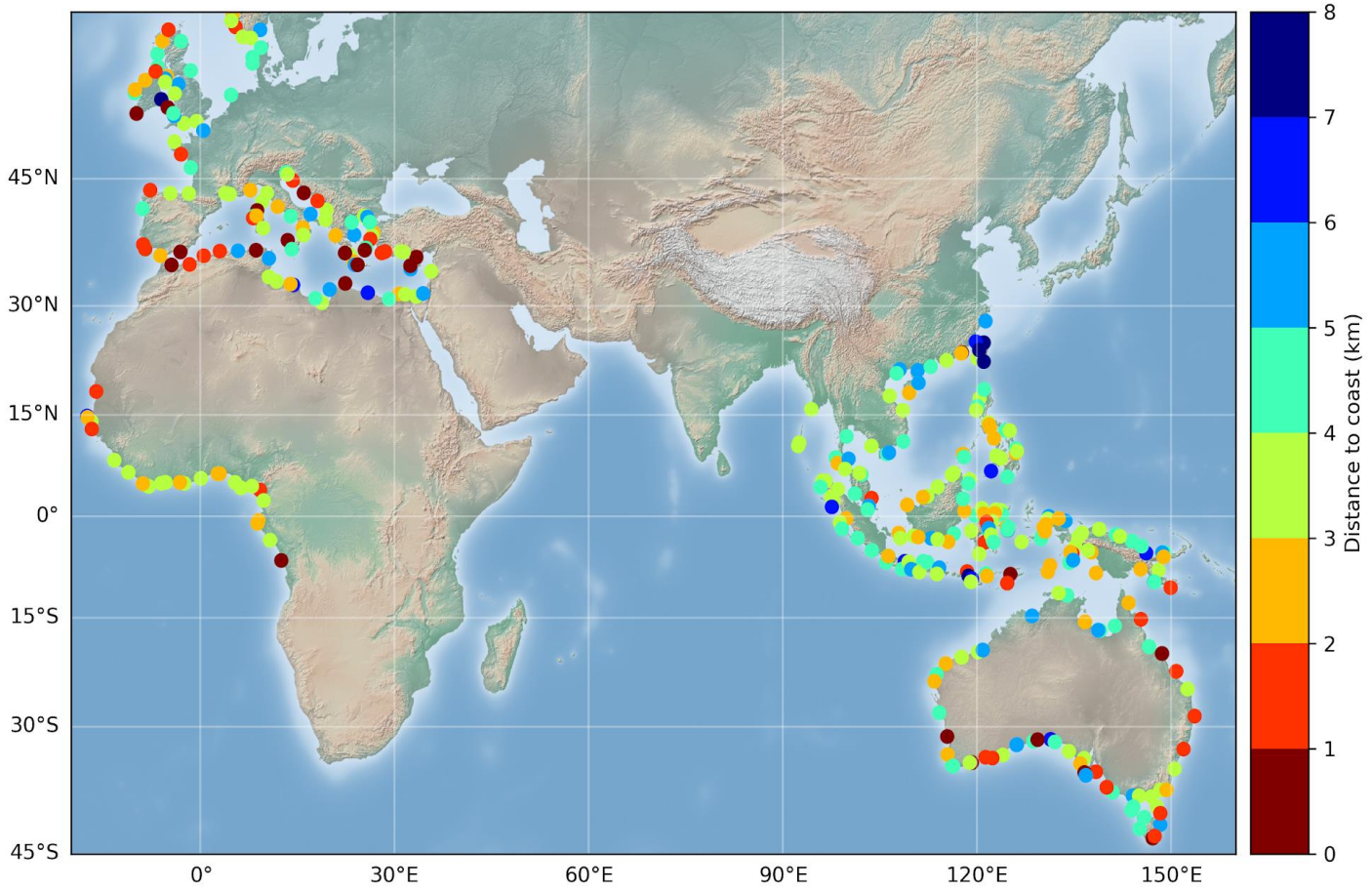
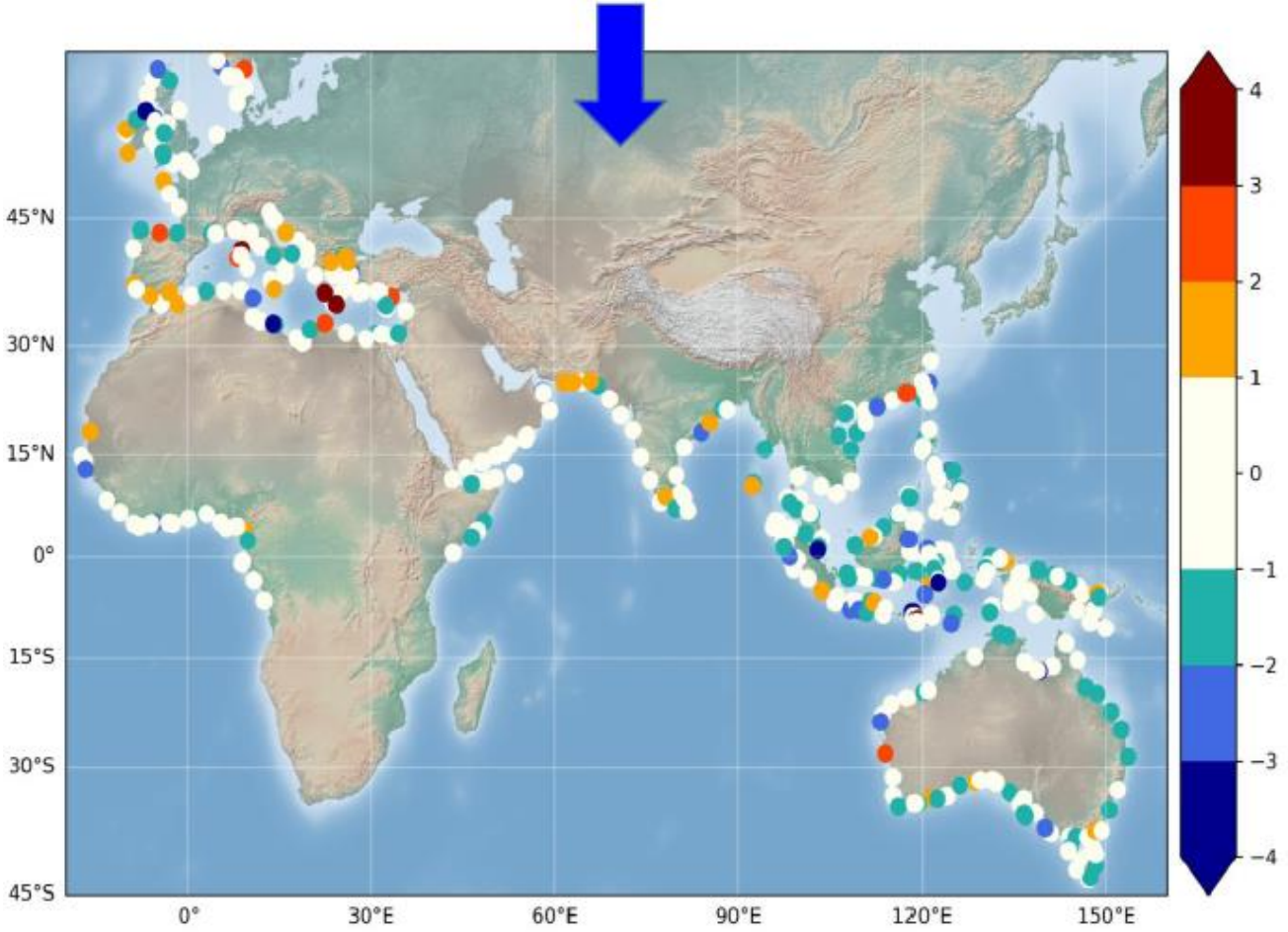


Fig.16 : Map of the closest distances to the coast at the 429 selected sites.

Is the sea level trend different at the coast?



Important result: in 80% of the studied sites, the trend at the coast does NOT differ from the open ocean trend (within +/- 1 mm/yr)

The Coastal Altimetry Community

Collaborations with ESA (example, two Essential Climate Variables currently focusing also on the coast)

Regular meetings and training courses, all material online: https://www.coastalt.eu/

Most recent review articles: Benveniste J., et al.: Requirements for a Coastal Hazards Observing System. Frontiers in Marine Science, 6, 10.3389/fmars.2019.00348, 2019

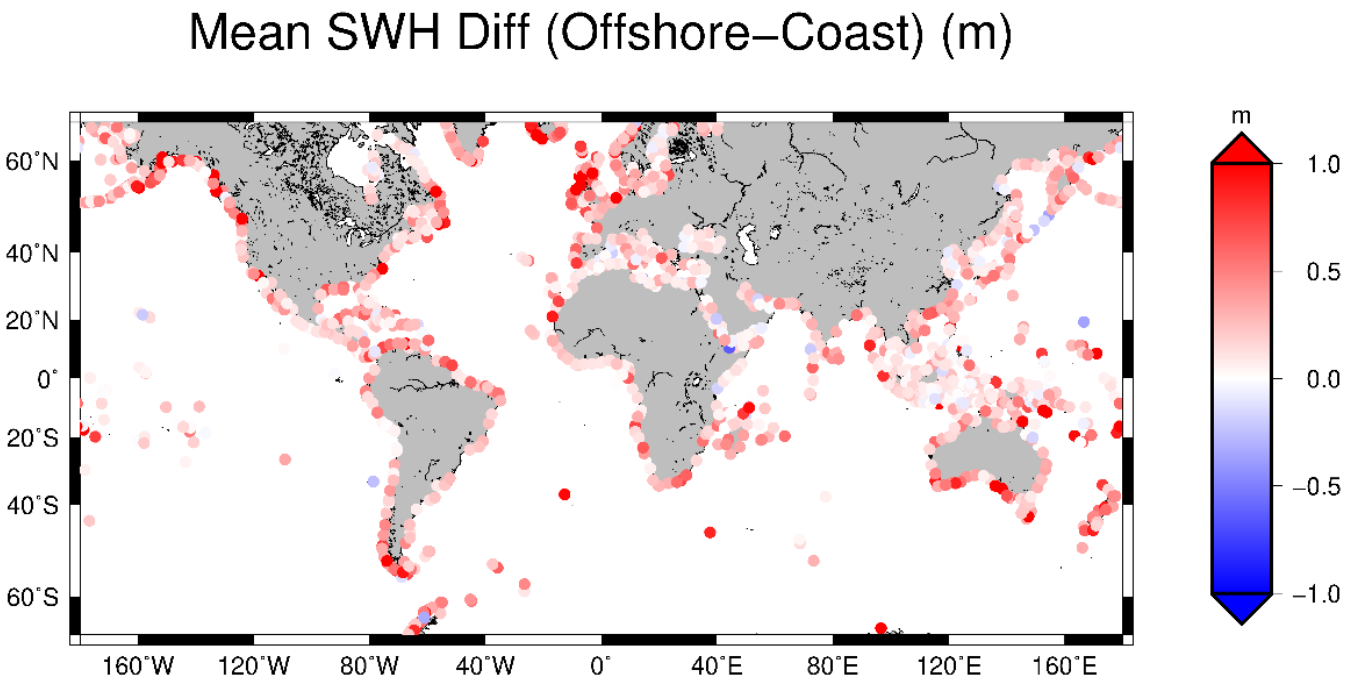
SPARE SLIDES

Coastal Wave Height

„The coastal sea level, as observed at the shores of exposed coastlines, is strongly influenced by wave-induced processes…long-term changes in wave conditions will likely affect coastal sea level”

From Dodet et al., 2019, https://doi.org/10.1007/s10712-019-09557-5

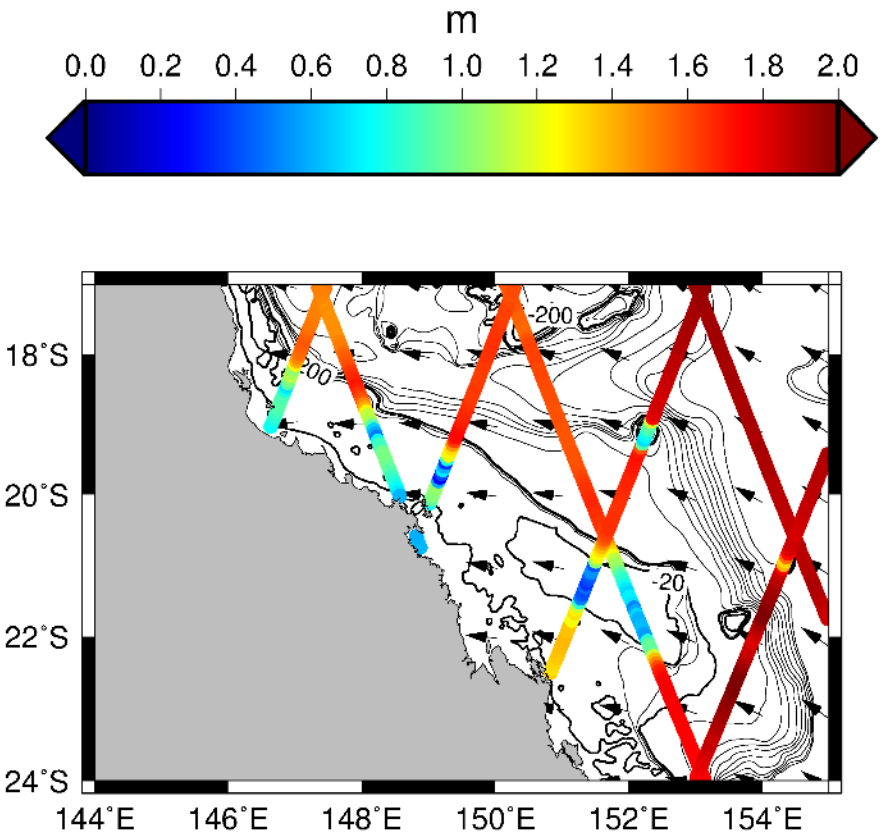
Mean coastal wave climate



Thinking Global: quantification of the coastal attenuation of wind waves from 30 km to 3 km from the coast

From *Passaro M., et al., 2021*. Nature Communications, 10.1038/s41467-021-23982-4

Mean coastal wave climate



Acting Local: the effect of the Great Barrier Reef as a defense against high sea states